Agilent Technologies 87050A Option H15

User's and Service Guide

Agilent Technologies
87050A Option H15

Multiport Test Set

User's and Service Guide

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Notices

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1 Agilent Technologies 87050A Option H15

Introduction

The Agilent 87050A Option H15 multiport test set is designed for use with Agilent Technologies 50 Ω network analyzers such as the Agilent 871x series, Agilent 8753D, and Agilent 8753E.

The test set provides the ability to make single connection, multiple measurements of multiport devices with up to 16 ports, such as distribution amplifiers, taps, switches, and couplers. Measurement throughput is increased by reducing the number of device reconnects the operator must perform. Switching is performed by mechanical switches.

The test set can be controlled by using an external GPIB (HP-IB) controller, or through parallel control.

NOTE This user's and service guide discusses the use of the test set with an Agilent 8753D or Agilent 8753E only.

For complete theory of operation information on the Agilent 87050A Option H15, refer to "Theory of Operation" on page 6-23 in this manual.

Installing the Test Set

This chapter will guide you through the steps necessary to correctly and safely install your multiport test set. The steps are:

1. Check the Shipment.
2. Meet Electrical and Environmental Requirements.

Step 1. Check the Shipment

1. After you have unpacked your test set, you should keep the original packaging materials so they can be used if you need to transport the instrument.
2. Check the items received against Table 1-1 to make sure that you have received everything.
3. Inspect the test set and all accessories for any signs of damage that may have occurred during shipment. If your test set or any accessories appear to be damaged or missing, call your nearest Agilent Technologies Sales or Service office. Refer to “Agilent Technologies Sales and Service Offices” on page 7-6 for the nearest office.

Table 1-1 Agilent 87050A Option H15 Accessories Supplied

Description	Agilent Part Number	Quantity
Power Cord	See Figure 3-3	1
Handle	5063-9228	1
Rack Kit	5063-9235	1
Parallel Cable	8120-6818	1
Semi-Flexible Cable, Type-N (m) to Type N (m)	8120-6995	2
Adapter, APC-7 to Type-N (f)	85054-60001	2
User's and Service Guide	87050-90029	1

Step 2. Meet Electrical and Environmental Requirements

1. The line power module on your test set is an autoranging input. It is designed to be used with an ac power source with a nominal voltage of either 115 V or
   230 V.
2. Ensure that the available ac power source meets the following requirements:

   90 to 250 Vac, 48 to 66 Hz, 40 W

CAUTION This product has an autoranging line voltage input. Be sure the supply voltage is within the specified range.

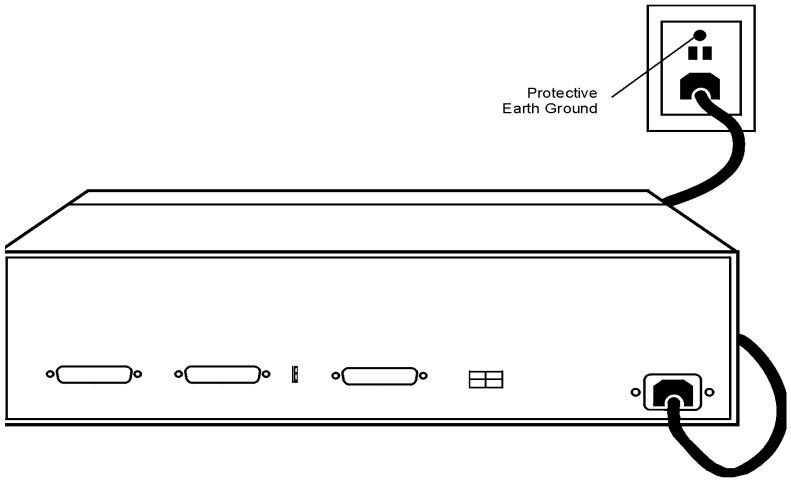
   If the ac line voltage is not within these ranges, use an autotransformer that provides third-wire continuity to earth-ground.

3. Ensure that the operating environment meets the following safety requirements for the following conditions:
   - indoor use
   - altitude up to 15,000 feet (4,572 meters)
   - temperature range of 0° C to 55° C
   - maximum relative humidity 80% for temperatures up to 31° C, decreasing linearly to 50% relative humidity
   - enclosure protection, IP 20, according to IEC 529

WARNING **This product is designed for use in INSTALLATION CATEGORY II, and POLLUTION DEGREE 2, per IEC 101 and 664 respectively.**

4. Verify that the power cable is not damaged, and that the power source outlet provides a protective earth-ground contact. Note that the following illustration depicts only one type of power source outlet. Refer to Figure 3-3 on page 3-6 to see the different types of power cord plugs that can be used with your test set.

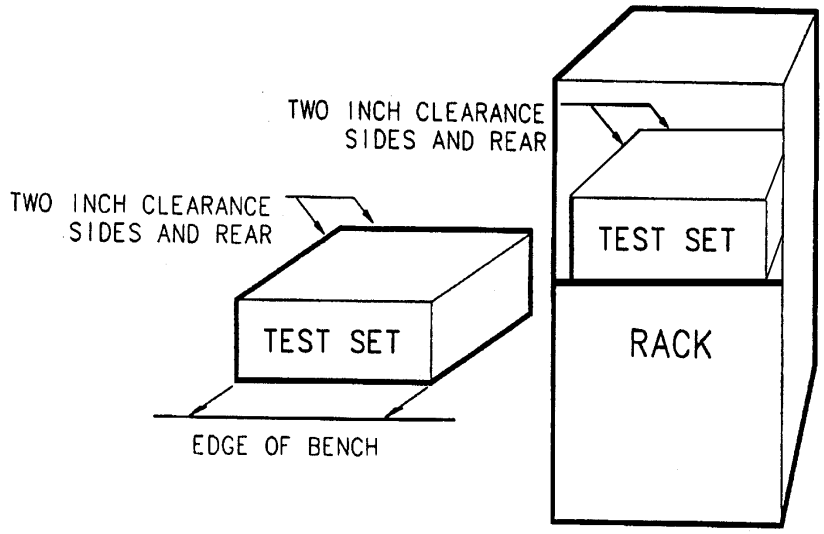
Figure 1-1 Protective Earth Ground



WARNING **This is a Safety Class I product (provided with a protective earth-ground incorporated in the power cord). The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

5. Ensure that there are at least two inches of clearance around the sides and back of the test set and the system cabinet (if used). Refer to Figure 1-2.

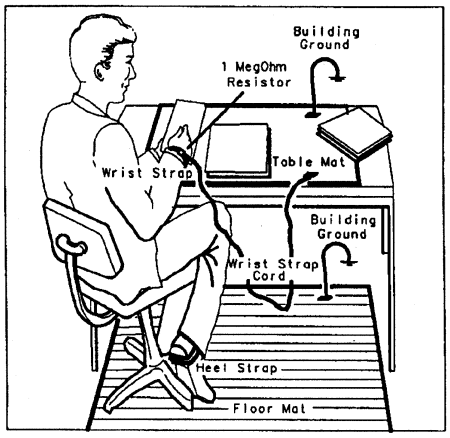
Figure 1-2 Ventilation Clearance Requirements



CAUTION Ventilation Requirements: When installing the instrument in a cabinet, the convection into and out of the instrument must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the instrument by 4° C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater that 800 watts, then forced convection must be used.

6. Set up a static safe workstation. Electrostatic discharge (ESD) can damage or destroy components.

Figure 1-3 Example of an Antistatic Workstation



- Table mat with earth ground wire, 9300-0797
- Wrist strap cord with 1 Meg Ohm resistor, 9300-0980
- Wrist strap, 9300-1367
- Heel Straps, 9300-1308
- Floor mat, part number 1864R

2 Getting Started

Getting Started

Connecting and Turning on the Test Set

The test set is designed to be placed underneath the network analyzer in a rack system and connected to it as shown in Figure 2-1 (if you are using a standard Agilent 8753D/E) or Figure 2-2 on page 2-3 (if you are using an Agilent 8753D/E Option 011 specifically). Use the two type-N (m) to type-N (m) semi-flexible cables (Agilent part number 8120-6995) and two APC-7 to type-N (f) adapters (Agilent part number 85054-60001) that were shipped with the test set. Refer to Table 1-1 on page 1-3.

Figure 2-1 Connecting the Test Set to the Agilent 8753E Network Analyzer

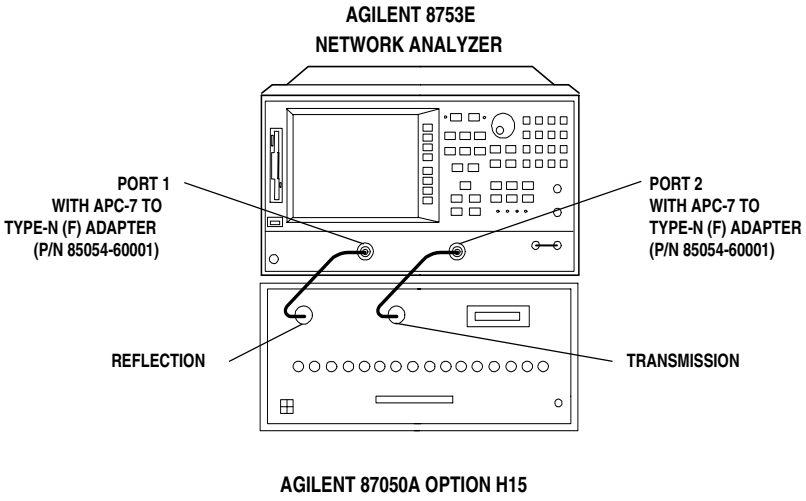
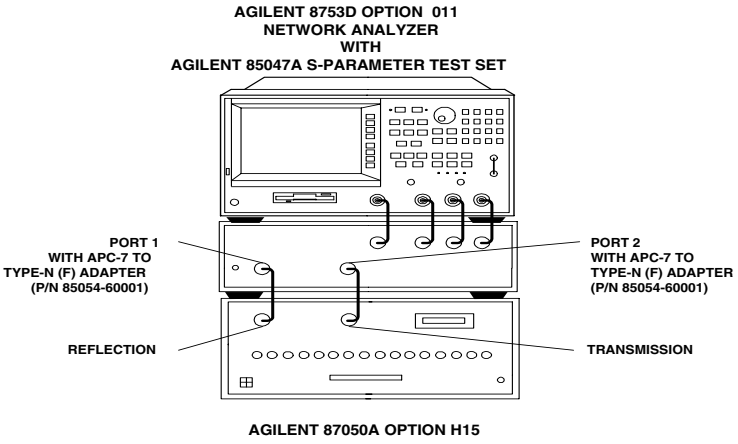


Figure 2-2 **Connecting the Test Set to the Agilent 8753D Option 011 Network Analyzer**



After all the proper connections have been made, turn on the test set using the front panel line switch. The front panel line switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.

NOTE For accurate, repeatable measurements, be sure to let the test set warm up for at least 2 hours. It is recommended that the test set not be turned off on a regular basis. For the most stable and accurate measurements, leave the test set turned on at all times.

Setting the Test Set Address Switch

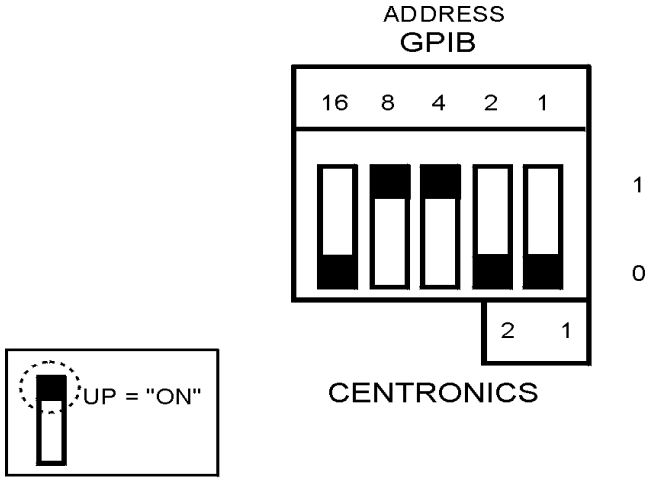
The test set is shipped with the GPIB (HP-IB) address set to 12, which sets the parallel address to 0 as in Figure 2-3 on page 2-4. Refer to “Introduction” on page 5-2 in this manual for the definition of the parallel address.

To set the GPIB (HP-IB) address, set all five switches so that the sum of the switches in the on or 1 position equals the desired address. In the example below, the two switches in the on position are 8 and 4, thus the GPIB (HP-IB) address of 12.

To set the parallel address, use only the number 1 switch. Therefore, the only possibilities for parallel port addressing are an address of 0 or 1.

When GPIB (HP-IB) is used, the parallel address is ignored.

Figure 2-3 The Test Set Address Switch



Performing the Operator's Check

For information on how to control the test set, refer to Chapter 5, "Controlling the Test Set and Making Measurements," on page 5-1.

Description

The following operator's check is designed to provide you with a high degree of confidence that your test set is working properly. It is not designed to verify specifications. To verify specifications, refer to Chapter 4, "Specifications," on page 4-1 in this manual.

This procedure is for performing a simple operator's check using a network analyzer of the proper frequency range and impedance.

Equipment Required

- Network Analyzer, 50 Ω impedance (Agilent 8753D/E)
- Adapter, APC-7 to type-N (f) (Agilent part number 85056-60001), quantity 2
- Cable, 50 Ω type-N (Agilent part number 8120-6995 or equivalent), quantity 2
- Calibration Kit, 50 Ω (Agilent 85032B)

Process

1. Connect the 50 Ω cable to Port 1 of the analyzer.
2. On the analyzer, perform a one-port reflection calibration at the end of the 50 Ω cable over the frequency range of 300 kHz to 6 GHz. Verify that the calibration is active and that a cable, terminated with a short, displays a return loss of 0 ±0.2 dB.
3. Connect the cable (already connected to Port 1 of the analyzer) to the reflection port of the Agilent 87050A Option H15 test set.
4. Using the network analyzer, measure the return loss of each section of the test set by selecting ports 1 through 16, one at a time. Terminate each port being tested with a 50 Ω load (greater than –30 dB). The resulting return loss should be greater than –12 dB (the absolute value should be greater than 12).

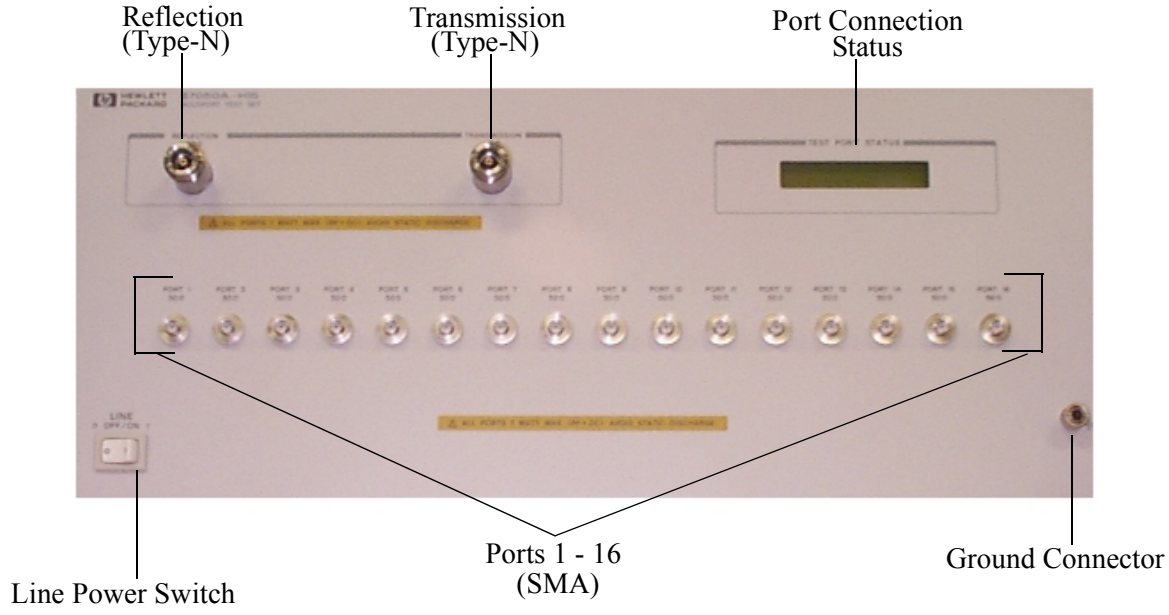
NOTE This is an 80% confidence test only. A unit could pass this simple test and yet still not function properly. For more complete testing, refer to "Performance Testing" on page 6-2.

3 The Front and Rear Panels

This chapter contains information about the ports and switches found on the front and rear panels of the test set. This chapter is divided into two sections: front panel and rear panel.

Front Panel

Figure 3-1 Front Panel



Line Power Switch

The test set line power switch is located at the bottom left corner of the front panel. See Figure 3-1. The line power switch turns the power to the test set either on or off.

The front panel line switch disconnects the mains circuits from the mains supply after the EMC filters and before other sections of the instrument.

Ports 1–16

Ports 1 through 16 are 50 Ω SMA connectors that are used to connect to the device under test.

CAUTION Do not input more than 1 watt (RF and DC combined) to these ports, or damage to the internal RF switches or the analyzer may occur.

The Transmission and Reflection Ports

The transmission and reflection ports are 50 Ω type-N connectors. A 50 Ω cable connects directly to the Reflection/Transmission port or Port 1/Port 2 of the network analyzer by means of the cables (Agilent part number 8120-6995) and adapters (Agilent part number 85054-60001) that were shipped with your test set.

CAUTION Check your analyzer documentation for power levels above which the ports can be damaged. Make sure that your test setup will not cause those levels to be exceeded.

The Ground Connector

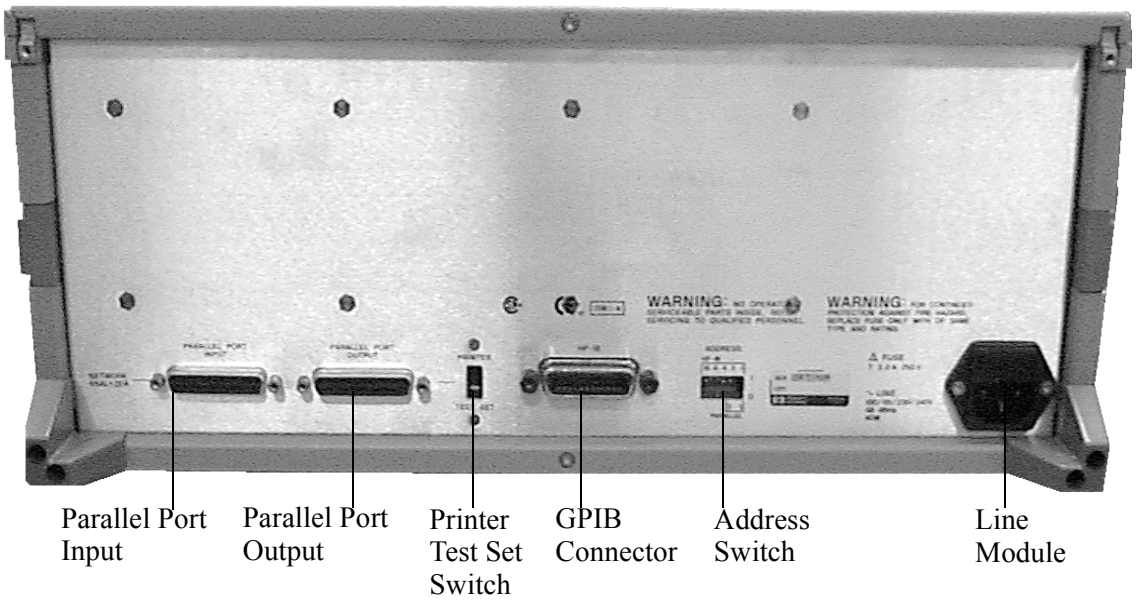
The ground connector on the front panel provides a convenient ground connection for a standard banana plug.

The Port Connection Status LCD

The port connection status LCD provides visual feedback of which port(s) are connected to the Transmission and Reflection ports of the test set. When the LCD displays a path connection, all other corresponding test ports are internally terminated in 50 Ω.

Rear Panel

Figure 3-2 **Rear Panel**



The Parallel Port Input Connector

This input is connected to the network analyzer. The analyzer provides control signals that drive the switches inside the test set. In pass-through mode, it also accepts signals required to drive a printer.

The Parallel Port Output Connector

The output from this connector is used either to control another test set, or to control a printer, depending upon how the Printer/Test Set switch is set.

The Printer/Test Set Switch

This switch determines the function of the Parallel Port Output connector. When switched to Printer, the Parallel Port Output will pass-through printer driver signals. When switched to Test Set, an additional test set can be controlled from the Parallel Port Output connector.

GPIB (HP-IB) Connector

This connector allows the test set to be connected directly to a controller that uses GPIB (HP-IB) commands. Refer to "Controlling the Test Set," Figure 5-3 on page 5-11.

Address Switch

The address switch sets either the GPIB (HP-IB) or the parallel address of the test set. See "Setting the Test Set Address Switch" on page 2-3 for information.

Line Module

The line module contains the power cable receptacle and the line fuse. The line module is an autoranging input and is designed to be used with an ac power source having a nominal voltage of either 115 V or 230 V. For fuse replacement information, refer to the section "Fuses" on page 3-7.

Power Cables

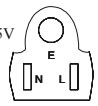
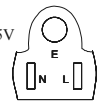
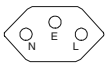
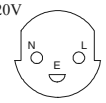
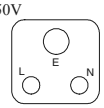
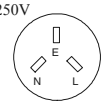
The line power cable is supplied in one of several configurations, depending on the destination of the original shipment.

Each instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument chassis. The type of power cable shipped with each instrument depends on the country of destination. Refer to "Power Cable and Line (Mains) Plug Part Number," Figure 3-3 on page 3-6 for the part numbers of these power cables. Cables are available in different lengths. Check with your nearest Agilent Technologies service center for descriptions and part numbers of cables other than those described in Figure 3-3. Refer to "Agilent Technologies Sales and Service Offices" on page 7-6 for the location closest to you.

CAUTION Always use the three-prong ac power cord supplied with this product. Failure to ensure adequate grounding by not using this cord may cause damage to the product.

WARNING **This is a Safety Class I product (provided with a protective earth-ground incorporated in the power cord). The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

Figure 3-3 **Power Cable and Line (Mains) Plug Part Number**

Plug Type [a]	Cable Part Number	Plug [b] Description	Length cm (in.)	Cable Color	For Use in Country
250V 	8120-8705 8120-8709	Straight BS 1363A 90˚	229 (90) 229 (90)	Mint Gray Mint Gray	Option 900 United Kingdom, Hong Kong, Cyprus, Nigeria, Singapore, Zimbabwe
250V 	8120-1369 8120-0696	Straight AS 3112 90˚	210 (79) 200 (78)	Gray Gray	Option 901 Argentina, Australia, New Zealand, Mainland China
125V 	8120-1378 8120-1521	Straight NEMA 5-15P 90˚	203 (80) 203 (80)	Jade Gray Jade Gray	Option 903 United States, Canada, Brazil, Colombia, Mexico,Philippines, Saudi Arabia, Taiwan
125V 	8120-4753 8120-4754	Straight NEMA 5-15P 90˚	229 (90) 229 (90)	Gray Gray	Option 918 Japan
250V 	8120-1689 8120-1692	Straight CEE 7/VII 90˚	200 (78) 200 (78)	Mint Gray Mint Gray	Option 902 Continental Europe, Central African Republic, United Arab Republic
230V 	8120-2104 8120-2296	Straight SEV Type 12 90˚	200 (78) 200 (78)	Gray Gray	Option 906 Switzerland
220V 	8120-2956 8120-2957	Straight SR 107-2-D 90˚	200 (78) 200 (78)	Gray Gray	Option 912 Denmark
250V 	8120-4211 8120-4600	Straight IEC 83-B1 90˚	200 (78) 200 (78)	Mint Gray Mint Gray	Option 917 South Africa, India
250V 	8120-5182 8120-5181	Straight SI 32 90˚	200 (78) 200 (78)	Jade Gray Jade Gray	Option 919 Israel

a. E =earth ground, L = line, and N = neutral.
b. Plug identifier numbers describe the plug only. The Agilent Technologies part number is for the complete cable assembly.

Fuses

The line fuse and a spare reside within the line module.
Figure 3-4 illustrates where the fuses are and how to access them.

Available Fuses

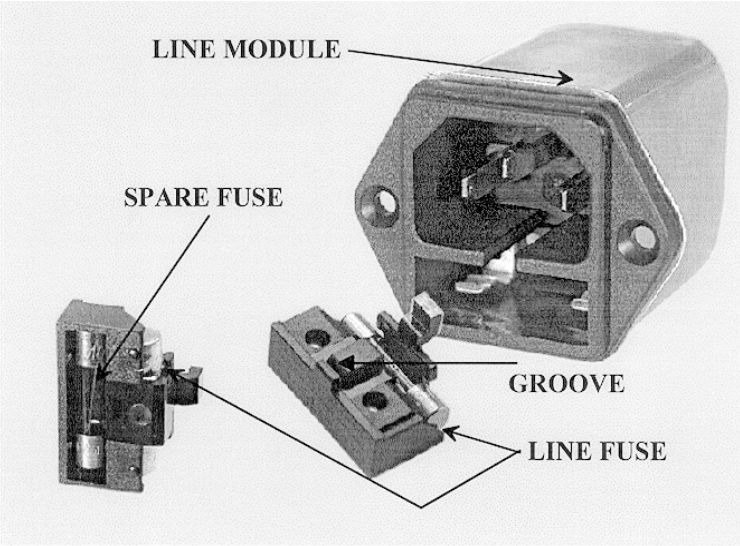
United States (115 V orientation)

- Fuse (F 3 A/250 V, Agilent part number 2110-0780), U.L. listed and CSA certified.

Europe (230 V orientation)

- Fuse (F 3.15 A/250 V, Agilent part number 2110-0655), IEC certified and U.L. recognized.

Figure 3-4 Location of Line Fuse



4 Specifications

Specifications

Table 4-1 **Agilent 87050A Option H15 Specifications**

Parameter	Specification
Frequency Range	300 kHz to 6.0 GHz
Insertion Loss	
300 kHz up to 1.3 GHz	≤1.5 dB
1.3 GHz up to 3.0 GHz	≤1.75 dB
3.0 GHz to 6.0 GHz	≤2.5 dB
Return Loss (Switch Path ON)	
300 kHz up to 1.3 GHz	≥25 dB
1.3 GHz up to 3.0 GHz	≥16 dB
3.0 GHz to 6.0 GHz	≥12 dB
Return Loss (Switch Path OFF)	
300 kHz up to 1.3 GHz	≥26 dB (typical)
1.3 GHz up to 3.0 GHz	≥21 dB (typical)
3.0 GHz to 6.0 GHz	≥15 dB (typical)
Isolation[a]	
300 kHz up to 3.0 GHz	≥100 dB
3.0 GHz to 6.0 GHz	≥90 dB
Input Power Damage Level	>1 watt (RF+DC)

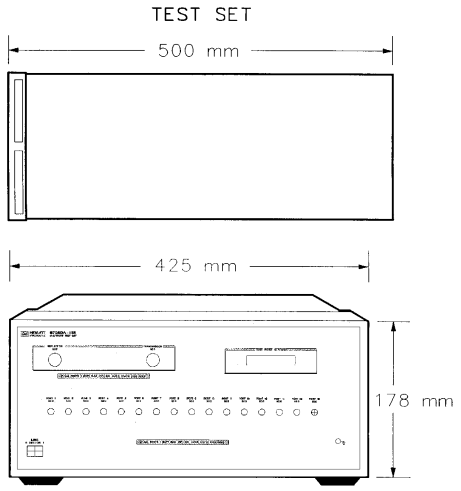
a. From Port to Port (1 through 16)

General Characteristics

Table 4-2 Environmental Characteristics

General Conditions ESD (electrostatic discharge) must be eliminated by means of static-safe work procedures and an antistatic workstation such as that illustrated in Figure 1-3 on page 1-7	
Operating Environment (for indoor use only)	
Altitude	up to 15,000 feet (4,572 meters)
Operating Temperature	0° C to 55° C
Maximum Relative Humidity	80% for temperatures up to 31° C, decreasing linearly to 50% relative humidity at 40° C
Enclosure protection IP 20, according to IEC 529	
This product is designed for use in INSTALLATION CATEGORY II, and POLLUTION DEGREE2, per IEC 101 and 664, respectively.	
Nonoperating Storage Conditions	
Temperature	–40° C to 70° C
Humidity	0 to 90% relative at 65° C (noncondensing)
Altitude	0 to 15,240 meters (50,000 feet)
Weight	Net: approximately 9 kg Shipping: approximately 20 kg
Cabinet Dimensions (These dimensions exclude front and rear panel protrusions)	178 mm H by 425 mm W by 500 mm D (7.02 in. by 16.75 in. by 19.7 in.)

Figure 4-1 Agilent 87050A Option H15 Physical Dimensions



If you need technical assistance, contact the nearest Agilent Technologies sales or service office. Refer to “Agilent Technologies Sales and Service Offices” on page 7-6 for the location closest to you.

5 Controlling the Test Set and Making Measurements

Introduction

The Agilent 87050A Option H15 is a “slave” instrument: a controller must be used to control the test set. There are three ways in which the test set can be controlled:

1. The controller can communicate to the network analyzer using GPIB (HP-IB) commands, which then controls the test set by the parallel connection.
2. The controller can control the test set directly by GPIB (HP-IB) commands.
3. A network analyzer equipped with a parallel connection can control the test set directly.

Commands

These three methods of control and their commands are detailed below and on the following pages.

Computer Control

The first method of controlling the test set is to write GPIB (HP-IB) commands to the network analyzer, which then writes the command to the test set by way of the parallel port. The following examples use the variable **D**, which is defined in Table 5-1 on page 5-6.

To use a parallel port connection with the Agilent 8753D,E, use an GPIB (HP-IB) command to write bits on the parallel port. The following example assumes that the address of the network analyzer is 16.

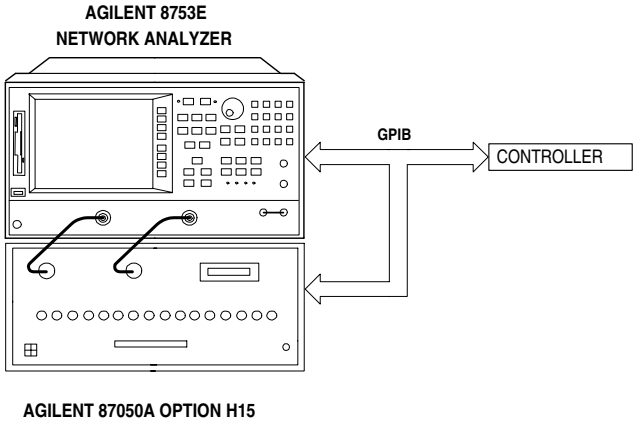
`OUTPUT 716;"PARALGPIO;"`	Sets the parallel port for GP-IO function
`OUTPUT 716;"PARAOUT[D];"`	Programs all GP-IO output bits (0 to 256) at once

NOTE Be sure to use the ending semicolon.

The second method of controlling the test set is to address the Agilent 87050A Option H15 test set directly over GPIB (HP-IB), using a controller to write directly to the test set's GPIB (HP-IB) port. See Figure 5-1 on page 5-4 for a diagram of connections for this type of control. The following example assumes that the address of the test set is 12.

```
OUTPUT 712;"command$"
```

Figure 5-1 Controlling the Test Set Over GPIB (HP-IB)



NOTE It is not necessary to have the test set connected to the network analyzer when you are controlling the test set over GPIB (HP-IB).

Network Analyzer Control

The third method of sending commands uses the network analyzer to control the test set directly. This method is performed with the standard setup of the network analyzer working with the test set. A parallel cable is connected from the network analyzer parallel output to the test set parallel input on the rear panels of both instruments.

NOTE

The following key conventions are used throughout this document.

- **[HARDKEYS]** are labeled keys on the instrument front panel.
- **SOFTKEYS** are unlabeled keys whose function is defined on the instrument display.
- Information shown on the instrument display is shown `LIKE THIS`.

The key labels can be either upper case or lower case.

1. Press **[SEQ]** > **TTL IO** > **PARALLEL OUT ALL**.
2. Use the arrow keys, ↑ or ↓ to scroll to the desired test port address, or input the number directly using the **[D]** > **[x1]**, where **D** represents the decimal value of the test port address.
   Refer to Table 5-1 on page 5-6.

Table 5-1 Test Port Addresses

Connection Path	Decimal [D]	Binary Equivalent	GPIB (HP-IB) Command
Reflection to Port 1	0	00000000	refl_01
Reflection to Port 2	1	00000001	refl_02
Reflection to Port 3	2	00000010	refl_03
Reflection to Port 4	3	00000011	refl_04
Reflection to Port 5	4	00000100	refl_05
Reflection to Port 6	5	00000101	refl_06
Reflection to Port 7	6	00000110	refl_07
Reflection to Port 8	7	00000111	refl_08
Reflection to Port 9	8	00001000	refl_09
Reflection to Port 10	9	00001001	refl_10
Reflection to Port 11	10	00001010	refl_11
Reflection to Port 12	11	00001011	refl_12
Reflection to Port 13	12	00001100	refl_13
Reflection to Port 14	13	00001101	refl_14
Reflection to Port 15	14	00001110	refl_15
Reflection to Port 16	15	00001111	refl_16
Reflection Terminated	16	00010000	j18-2
Transmission to Port 1	17	00010001	tran_01
Transmission to Port 2	18	00010010	tran_02
Transmission to Port 3	19	00010011	tran_03
Transmission to Port 4	20	00010100	tran_04
Transmission to Port 5	21	00010101	tran_05
Transmission to Port 6	22	00010110	tran_06
Transmission to Port 7	23	00010111	tran_07
Transmission to Port 8	24	00011000	tran_08
Transmission to Port 9	25	00011001	tran_09
Transmission to Port 10	26	00011010	tran_10
Transmission to Port 11	27	00011011	tran_11
Transmission to Port 12	28	00011100	tran_12
Transmission to Port 13	29	00011101	tran_13
Transmission to Port 14	30	00011110	tran_14
Transmission to Port 15	31	00011111	tran_15
Transmission to Port 16	32	00100000	tran_16
Transmission Terminated	33	00100001	j19-2
All Ports Terminated into 50 Ω	34	00100010	*all_term
Reset, Reflection-Port 1 and Transmission-Port 2	35	00100011	*rst
Serial Number			sn?

To connect all ports to their internal 50 Ω loads, send the following command:

```
OUTPUT 712;"*all_term;"
```

NOTE When a test set port is not in use, it is terminated in 50 Ω.

If the Agilent 87050A Option H15 is being controlled by GPIB (HP-IB), you can read the serial number of the test set by sending the following commands:

```
OUTPUT 712;"sn?"

ENTER 712:Sn$

DISP Sn$
```

When the RESET command is sent, the test set is set to a known state where the Reflection port is directed to Port 1 and the Transmission port is directed to Port 2.

Refer to the Option H15 block diagram, Figure 6-1 on page 6-22, for the switch paths.

The switch count represents the number of times each switch has been activated. To read the individual switch count, send the following command:

```
OUTPUT 712;"SW11?"

ENTER 712; COUNT$

DISP COUNT$
```

The above example shows the SW11 command only. To enter additional commands use Table 5-2 on page 5-8.

Table 5-2 Switch Number GPIB Command

Switch Number	GPIB (HP-IB) Command
S10	SW10?
S11	SW11?
S12	SW12?
S14	SW14?
S15	SW15?
S16	SW16?
S18	SW18?
S19	SW19?
S51	SW51?
S53	SW53?
S55	SW55?
S57	SW57?
S62	SW62?
S63	SW63?
S64	SW64?
S65	SW65?
S66	SW66?
S67	SW67?
S68	SW68?
S69	SW69?
S70	SW70?
S71	SW71?
S72	SW72?
S74	SW74?

To enter commands for activating each switch port individually, use the switch-port identifier. For example, use the GPIB (HP-IB) command J18-2 for switch-port J18-2, and J51-1 for switch-port J51-1, and so on.

Calibrating the Test System

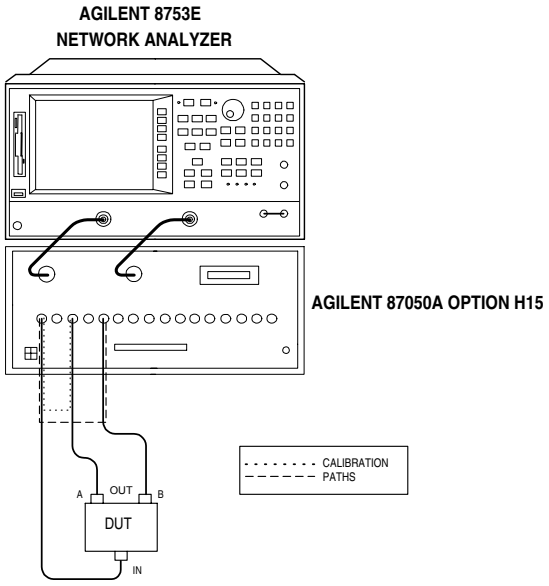
After the test set has warmed up for at least two hours, you should calibrate it before making any measurements. Refer to your network analyzer user's guide to determine the type of calibration appropriate for the measurements you will be making.

You will need to calibrate each measurement path separately and store the calibration as an instrument state in the network analyzer. Refer to your network analyzer user's guide for information on how to calibrate and store instrument states.

Refer to Figure 5-2. In this example setup the following tests will be made:

- Return loss on the DUT's input and two output ports (A and B)
- Insertion loss (or gain) between the DUT's input and port A
- Insertion loss (or gain) between the DUT's input and port B

Figure 5-2 Calibrating the Test System



For the best accuracy, you should perform a full two-port calibration between test set ports 1 and 2, and again between ports 1 and 3. As mentioned before, you need to save the calibrations as instrument states. See your analyzer user's guide for information on calibrations and saving instrument states.

CAUTION When performing a full two-port calibration and making subsequent measurements, you must use the transfer switch internal to the Agilent 8753D/E to change the direction of the RF signal path. Do not use the test set to change the direction of the RF signal path when you are using a full two-port calibration. Doing so will render the calibration invalid.

Making Measurements

The following examples assume that you are using a parallel port connection with an Agilent 8753D/E, with the test set parallel address set to 0. Refer to “Setting the Test Set Address Switch” on page 2-3, for information on setting the test set address.

Measuring Transmission

Refer to Figure 5-3 on page 5-11 for the following discussion. With the Agilent 8753D/E set to measure forward transmission (S_{21}), the analyzer RF source is being output through the analyzer Port 1, and Port 2 is set to receive the RF signal.

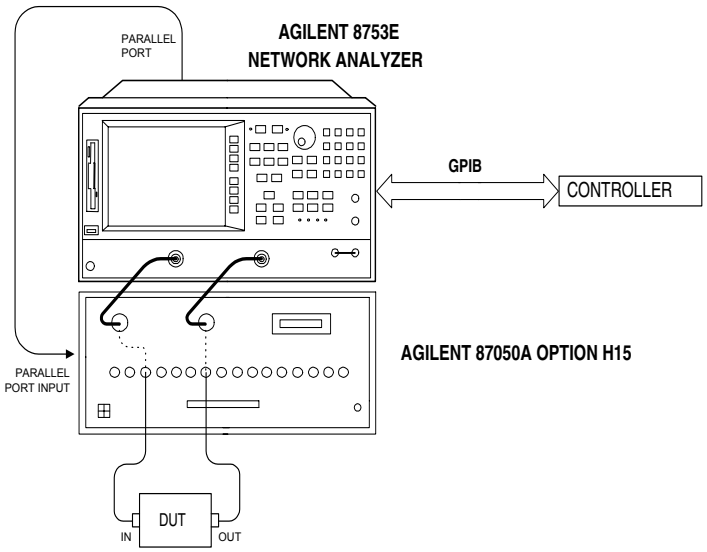
By using the following commands, you will connect Port 3 of the test set to the Reflection port, and you will connect Port 7 of the test set to the Transmission port. You will thus be measuring forward transmission through the device under test when measuring S_{21}. This will provide you with gain or insertion loss information.

```
OUTPUT 716;"PARALGPIO;"

OUTPUT 716;”PARAOUT2;”

OUTPUT 716;”PARALGPIO;”

OUTPUT 716;”PARAOUT6;”
```

If controlling the Agilent 87050A Option H15 directly, use the following GPIB (HP-IB) commands:

```
OUTPUT 712;"refl_03"

ENTER 712;”tran_07”
```

Figure 5-3 Controlling the Test Set



Measuring Reflection

By leaving the DUT connected as in Figure 5-3, and setting the network analyzer to measure S11, you can measure reflection or return loss.

Example Program

An example program for making measurements is briefly described and listed on the following pages. This program is written in HP BASIC and is for use with an HP 9000 series 200/300/700 computer. Use this example program to create a program for your specific needs.

The Control Program

The Control program demonstrates the control of the Agilent 87050A Option H15 by GPIB (HP-IB) commands or the parallel port. This program can be used to select any port combination manually (listed on the following pages). This program will first ask the user which method will be used to control the Agilent 87050A Option H15, either GPIB (HP-IB) or parallel port. It will then ask which ports are to be enabled. The port entries are done in pairs (reflection/transmission) with the two numbers separated by a comma. The numbers may range from 0 through 16 for the test ports. For example, an entry of 2,5 will connect the Reflection port to Port 2 and the Transmission port to Port 5. The program is a continuous loop. Press STOP to end program execution.

```
10      ! RE-SAVE "control"

20      ! CONTROL:  This example program allows "manual"
                    control of the

30      !           Agilent 87050A Option H15 via the parallel
                     port of the

40      !           Agilent 8753D,E network analyzer or via
                     GPIB directly.

50      !

60      ! NOTE:     You MUST select either GPIB control or
                    Parallel Port

70      !          control.  If Parallel Port via the Agilent
                    8753D,E is

80      !          selected, this program will return the
                    analyzer to

90      !          LOCAL control after the switches are set.


100     !

110     !          Set the GPIB address as required below.

120     !

130     !         The Agilent 87050A Option H15 can be set to
                   one of two

140     !         Parallel Port addresses.  This program (SUB
                   Set_switches)

150     !          assumes it is set to address 00.

160     !

170     !          Copyright:  Agilent Technologies Co. Palo
Alto,                    CA 94304
```

```
180    !
190    !          Developed at Microwave Instruments Division
                   Santa Rosa, CA
200    !           Revision A.01.00     05 May 1998     rm
210    Nwa_addr=716
220    Ts_addr=712
230    !
240    CLEAR SCREEN
250    PRINT USING "3/,K,/";"*****    DEMONSTRATION PROGRAM
       FOR Agilent 87050A-H15        MANUAL CONTROL    *****"
260    PRINT "Either direct GPIB control of the Agilent
       87050A-H15 may be selected (h),"
270    PRINT "or indirect control via the Parallel Port (p)
       of the Agilent 8753D,E"
280    REPEAT
290        Answ$="p"
300        OUTPUT 2;Answ$&CHR$(255)&"H";
310        BEEP 300,.1
320        INPUT "Select desired test-set control.  GPIB or
           Parallel Port? (Enter H or P)",Answ$
330        Answ$=UPC$(Answ$[1,1])
340    UNTIL Answ$="P" OR Answ$="H"
350    Controller$=Answ$
360    !
370    ABORT 7
380    CLEAR SCREEN
390    IF Controller$="P" THEN
400       Addr=Nwa_addr      ! Assign address to the analyzer
410        PRINT "Test set is being controlled via Parallel
           Port; Agilent 8753D,E address =";Addr
420    ELSE
430        Addr=Ts_addr
440        PRINT "Test set is being controlled directly via
           GPIB.  GPIB address =";Addr
450    END IF
460    Isc=Addr DIV 100       ! Interface Select Code
```

```
470    !
480    PRINT USING "/,K,/";RPT$("-",77)
490    PRINT "For manual operation of this switch box, enter
       TWO numbers separated by"
500    PRINT "a comma (,).  The two numbers represent the
       port numbers directed to the"
510    PRINT "Reflection Port and Transmission Port,
       respectively.  Setting a port to"
520    PRINT "'0' will terminate the corresponding port."
530    PRINT "Unless both numbers are '0', the two values
       cannot be the same."
540    PRINT "To terminate the program, press STOP or PAUSE."
550    PRINT
560    PRINT "Example:  1,2  sets the test set paths Port 1 to
       Reflection Port and"
570    PRINT " Port 2 to Transmission Port."
580    PRINT " 10,1  sets the test set paths Port 10 to
       Reflection Port and"
590    PRINT " Port 1 to Transmission Port."
600    PRINT " 0,5  sets the test set paths Reflection Port
       terminated and"
610    PRINT " Port 5 to Transmission Port."
620    PRINT "          0,0  sets the test set paths to
       terminate both Reflection and"
630    PRINT " Transmission ports."
640    PRINT " all_term  sets the test set paths to terminate
       all ports"
650    PRINT " reset  sets the test set to known paths, i.e.,
       Reflection Port"
660    PRINT " to Port 1 and Transmission Port to Port 2."
670    PRINT
680    PRINT "If you have selected GPIB you may also check
       the serial number of"
690    PRINT "the unit by typing 'serial', or check the
       number of times the switch"
700    PRINT "has switched by typing 'switch ##', where ## is
       the number of the"
710    PRINT "desired switch."
```

```
720    LOOP
730        Refl=0
740        Trans=0
750        BEEP 500,.1
760       LINPUT "Enterthe Reflection Port/Transmission Port
           selections separated by commas: e.g. 1,2
           ",Command$
770        Current_pos=POS(Command$,",")
780        Command_length=LEN(Command$)
790        Counter=0
800        Cmd$=Command$
810        IF Current_pos>0 THEN
820            WHILE Current_pos>0
830                Command_length=LEN(Command$)
840                Current$=Command$[1,(Current_pos-1)]
850                Command$=Command$[(Current_pos+1),Command
                   _length]
860                Current_pos=POS(Command$,",")
870                Set_no=VAL(Current$)
880                SELECT Counter
890                CASE 0
900                    Refl=Set_no
910                CASE ELSE
920                    PRINT TABXY(1,29),"Too many numbers
                       entered.  Try again!  Entered ";Cmd$
930                    BEEP 500,.1
940                    WAIT 1
950                END SELECT
960                Counter=Counter+1
970            END WHILE
980            Set_no=VAL(Command$)
990            Trans=Set_no
1000           PRINT TABXY(1,29),"                              "
1010          IF NOT (((Refl<>Trans) OR (Refl=0 AND Trans=0)
                OR (Trans=16 AND Refl=16)) AND Refl<17 AND
                Trans<17 AND Refl>=0 AND Trans>=0) THEN
```

```
1020              DISP "Port selections MUST be different if
                   non-zero; Range= 0 to 16.
                   Entered """&Current$&","&Command$&""""
1030               BEEP 1500,.3
1040               WAIT 5
1050           ELSE
1060               Set_switches(Addr,"REFL",VAL$(Refl),
                   Controller$)
1070            ! Sets Ports
1080               Set_switches(Addr,"TRANS",VAL$(Trans),
                   Controller$)
1090            ! Sets Ports
1100              PRINT TABXY(1,28),"                          "
1110              PRINT TABXY(1,28),"Current Port = ";Refl;"
                   to Reflection Port"
1120              PRINT TABXY(1,29),"                          "
1130             PRINT TABXY(1,29),"Current Port = ";Trans;"
                   to Transmission Port"
1140           END IF
1150       ELSE
1160           SELECT UPC$(Command$)
1170           CASE "SERIAL"
1180               OUTPUT 712;"sn?"
1190               ENTER 712;Sn$
1200               PRINT TABXY(1,29),"                          "
1210               PRINT TABXY(1,29),"serial number is ";Sn$
1220           CASE "ALL_TERM"
1230               IF Controller$="H" THEN
1240                   Output_cmd$="*all_term"
1250                   OUTPUT Addr;Output_cmd$
1260               ELSE
1270                   Output_cmd$="34"
1280                   OUTPUT Addr;"PARALGPIO;"
1290                   OUTPUT Addr;"PARAOUT"&Output_cmd$&";"
1300               END IF
1310              PRINT TABXY(1,28),"                          "
```

```
1320              PRINT TABXY(1,29),"                          "
1330            PRINT TABXY(1,28),"All ports are terminated
                  into 50 ohms."
1340          CASE "RESET"
1350              IF Controller$="H" THEN
1360                  Output_cmd$="*rst"
1370                 OUTPUT Addr;Output_cmd$              !
                      sent via GPIB
1380              ELSE
1390                  Output_cmd$="35"
1400                  OUTPUT Addr;"PARALGPIO"
1410                OUTPUT Addr;"PARAOUT"&Output_cmd$&";"!
                      sent via Centronics Port
1420              END IF
1430              PRINT TABXY(1,28),"                          "
1440              PRINT TABXY(1,29),"                          "
1450              PRINT TABXY(1,28),"Test set reset; Port 1
                  to REFL & Port 2 to TRANS."
1460          CASE ELSE
1470              Command$=UPC$(Command$)
1480              IF POS(Command$,"SWITCH") THEN
1490                  Nu$=TRIM$(Command$[8,Command_length])
1491                  SELECT Nu$
1492                CASE "10","11", "12", "14","15", "16",
                      "18", "19", "51", "53", "55", "57",
                      "62" TO "72", "74"
1510                      OUTPUT 712;"sw"&Nu$;"?"
1520                      ENTER 712;Count$
1530                     PRINT TABXY(1,30),"               "
1540                      PRINT TABXY(1,30),"switch number
                          ";Nu$;" has ";Count$
1550                  CASE ELSE
1560                    DISP "Installed switch numbers are
                          10, 11, 12, 14, 15, 16, 18, 19,
                          51, 53, 55, 57, 62 thru 72 and 74.
                          Try again!  Entered ";Command$
1570                      BEEP 300,.1
```

```
1580                        WAIT 3
1590                     END SELECT
1600                ELSE
1610                   DISP "Unknown command """;Command$;""""
1620                     BEEP 300,.1
1630                     WAIT 3
1640                END IF
1650             END SELECT
1660          END IF
1670    END LOOP
1680    END
1690    !
1700    SUB Set_switches(Addr,First_parm$,Second_parm$, Contr
oller$)
1710    !=====================================================
1720    !  PURPOSE:To set the Agilent 87050A Option H15
switches.
1730    !-----------------------------------------------------
1740    !
1750    !  PARAMETERS:
1760    !
1770    !  Controller$:       [P|H]  P=Parallel via Agilent
                               8753D,E   or  H=GPIB
1780    !  First_parm$:       [REFL|TRANS]
1790    !  Second_parm$:      [0|1|2|...16]
1800    !  Addr:             GPIB addr of Agilent 8753D,E or
                               Agilent 87050A-H15 depending
1810    !                     on H or P above.
1820    !-----------------------------------------------------
1830    !
1840    !  DESCRIPTION:
1850    !
1860    !  Commands can be sent via Centronics (Parallel) port
           or via GPIB
1870    !  Choice depends upon variable Controller$ [P|H]
1880    !
```

```
1890   !=================================================
1900 Set_switches:   !
1910   !
1920       SELECT UPC$(TRIM$(First_parm$))
1930       CASE "REFL"
1940           SELECT UPC$(TRIM$(Second_parm$))
1950           CASE "0","TERMINATE REFLECTION"
1960               Hswitch_code$="*r_term"
1970               Pswitch_code$="16"
1980           CASE "1","PORT 1 TO REFLECTION"
1990               Hswitch_code$="refl_01"
2000               Pswitch_code$="0"
2010           CASE "2","PORT 2 TO REFLECTION"
2020               Hswitch_code$="refl_02"
2030               Pswitch_code$="1"
2040           CASE "3","PORT 3 TO REFLECTION"
2050               Hswitch_code$="refl_03"
2060               Pswitch_code$="2"
2070           CASE "4","PORT 4 TO REFLECTION"
2080               Hswitch_code$="refl_04"
2090               Pswitch_code$="3"
2100           CASE "5","PORT 5 TO REFLECTION"
2110               Hswitch_code$="refl_05"
2120               Pswitch_code$="4"
2130           CASE "6","PORT 6 TO REFLECTION"
2140               Hswitch_code$="refl_06"
2150               Pswitch_code$="5"
2160           CASE "7","PORT 7 TO REFLECTION"
2170               Hswitch_code$="refl_07"
2180               Pswitch_code$="6"
2190           CASE "8","PORT 8 TO REFLECTION"
2200               Hswitch_code$="refl_08"
2210               Pswitch_code$="7"
2220           CASE "9","PORT 9 TO REFLECTION"
```

```
2230              Hswitch_code$="refl_09"
2240              Pswitch_code$="8"
2250           CASE "10","PORT 10 TO REFLECTION"
2251              Hswitch_code$="refl_10"
2252              Pswitch_code$="9"
2255           CASE "11","PORT 11 TO REFLECTION"
2256              Hswitch_code$="refl_11"
2257              Pswitch_code$="10"
2260           CASE "12","PORT 12 TO REFLECTION"
2262              Hswitch_code$="refl_12"
2263              Pswitch_code$="11"
2265           CASE "13","PORT 13 TO REFLECTION"
2267              Hswitch_code$="refl_13"
2268              Pswitch_code$="12"
2270           CASE "14","PORT 14 TO REFLECTION"
2272              Hswitch_code$="refl_14"
2273              Pswitch_code$="13"
2280           CASE "15","PORT 15 TO REFLECTION"
2282              Hswitch_code$="refl_15"
2283              Pswitch_code$="14"
2284           CASE "16","PORT 16 TO REFLECTION"
2285              Hswitch_code$="refl_16"
2286              Pswitch_code$="15"
2287           CASE ELSE
2288              DISP "Unrecognized switched port
                  parameters;  """&First_parm$&""" to
                  """&Second_parm$&""""
2289              BEEP 1500,.1
2290              WAIT 2
2291           END SELECT
2292        CASE "TRANS"
2293           SELECT UPC$(TRIM$(Second_parm$))
2294           CASE "0","TERMINATE TRANSMISSION"
2295              Hswitch_code$="*t_term"
```

```
2296              Pswitch_code$="33"
2297          CASE "1","PORT 1 TO TRANSMISSION"
2298              Hswitch_code$="tran_01"
2299              Pswitch_code$="17"
2300          CASE "2","PORT 2 TO TRANSMISSION"
2301              Hswitch_code$="tran_02"
2302              Pswitch_code$="18"
2303          CASE "3","PORT 3 TO TRANSMISSION"
2304              Hswitch_code$="tran_03"
2305              Pswitch_code$="19"
2306          CASE "4","PORT 4 TO TRANSMISSION"
2307              Hswitch_code$="tran_04"
2308              Pswitch_code$="20"
2309          CASE "5","PORT 5 TO TRANSMISSION"
2310              Hswitch_code$="tran_05"
2311              Pswitch_code$="21"
2312          CASE "6","PORT 6 TO TRANSMISSION"
2313              Hswitch_code$="tran_06"
2314              Pswitch_code$="22"
2315          CASE "7","PORT 7 TO TRANSMISSION"
2316              Hswitch_code$="tran_07"
2317              Pswitch_code$="23"
2318          CASE "8","PORT 8 TO TRANSMISSION"
2319              Hswitch_code$="tran_08"
2320              Pswitch_code$="24"
2321          CASE "9","PORT 9 TO TRANSMISSION"
2322              Hswitch_code$="tran_09"
2323              Pswitch_code$="25"
2324          CASE "10","PORT 10 TO TRANSMISSION"
2325              Hswitch_code$="tran_10"
2326              Pswitch_code$="26"
2327          CASE "11","PORT 11 TO TRANSMISSION"
2328              Hswitch_code$="tran_11"
2329              Pswitch_code$="27"
```

```
2330            CASE "12","PORT 12 TO TRANSMISSION"
2331                Hswitch_code$="tran_12"
2332                Pswitch_code$="28"
2333            CASE "13","PORT 13 TO TRANSMISSION"
2334                Hswitch_code$="tran_13"
2335                Pswitch_code$="29"
2336            CASE "14","PORT 14 TO TRANSMISSION"
2337                Hswitch_code$="tran_14"
2338                Pswitch_code$="30"
2339            CASE "15","PORT 15 TO TRANSMISSION"
2340                Hswitch_code$="tran_15"
2341                Pswitch_code$="31"
2342            CASE "16","PORT 16 TO TRANSMISSION"
2343                Hswitch_code$="tran_16"
2344                Pswitch_code$="32"
2345            CASE ELSE
2346                DISP "Unrecognized switched port
                    parameters;  """&First_parm$&""" to
                    """&Second_parm$&"""
2347                BEEP 300,.1
2348                WAIT 2
2349            END SELECT
2350        END SELECT
2351    !
2352        IF Controller$="H" THEN
2353            Output_cmd$=TRIM$(Hswitch_code$)
2354            OUTPUT Addr;Output_cmd$ ! sent via GPIB
2355        ELSE
2356            Output_cmd$=VAL$(VAL(Pswitch_code$))
2357            OUTPUT Addr;"PARALGPIO;"
2358            OUTPUT Addr;"PARAOUT"&Output_cmd$&";"! sent
                via Centronics Port
2359        END IF
2360        WAIT .1
2361    SUBEND
```

6 Servicing the Test Set

This chapter contains information about the following:

- performance testing
- performance test record
- replaceable parts
- troubleshooting the test set
- theory of operation

CAUTION Read all applicable safety warnings and cautions in Chapter 7, “Safety and Regulatory Information,” on page 7-1, before servicing the test set.

Performance Testing

Performance testing consists of measuring insertion loss, return loss, and isolation between all ports.

NOTE For the most accurate measurements, the use of an Agilent 8753D/E 50 Ω network analyzer is recommended and its use is assumed in these testing instructions. Familiarity with RF and microwave measurements is also assumed.

The use of adapters may be required and their effects should be accounted for. Performance tests will require the following equipment:

- Agilent 8753D/E Network Analyzer (with Option 006 to test to 6 GHz)
- Test Port Extension Cables
- Agilent 85032B Calibration Kit, Type-N, 50 Ω
- Agilent 85033x Calibration Kit, 3.5 mm, 50 Ω
- Agilent 909D or Agilent p/n 00909-60009, 50 Ω Load

NOTE Make a photocopy of the performance test record (later in this chapter) to record the results of the performance tests.

There are no adjustments required for the Agilent 87050A Option H15 test set.

Set up the network analyzer using the following procedure.

Step 1. Set the number of points to 401 by pressing:
[MENU] > **NUMBER OF POINTS** > **[401]**

Step 2. Set the IF Bandwidth to 10 Hz by pressing:
[AVG] > **IF** > **BW** > **[10]** > **[x1]**

Step 3. Connect the test port cables to Port 1 and Port 2 on the network analyzer.

Step 4. Connect the parallel port connector from the network analyzer to the test set.

Step 5. Set the parallel port to “GPIO” by pressing:
[LOCAL] > **PARALLEL** > **GPIO**

Step 6. Set the network analyzer to utilize internal memory by pressing:
[SAVE/RECALL] > **SELECT DISK** > **INTERNAL DISK**

Adapter Delay Removal

Step 1. Perform an S11 calibration on Port 1 of the network analyzer.

Step 2. Connect the 3.5 mm end of the 3.5 mm to APC-7 adapter, Agilent part number 1250-1747, directly to Port 1 of the network analyzer.

Step 3. Connect a 7 mm short to the APC-7 side of the connector

Step 4. Set the analyzer to polar format by pressing:
[FORMAT] > POLAR

Step 5. Press:
[CAL] > MORE > PORT EXTENSIONS > EXTENSIONS ON > EXTENSIONS INPUT 1

Step 6. Using the front panel knob, set the extension to remove phase offset. The CRT should display a ball located on the right side of the graph when the phase offset is removed.

Step 7. Record the port extension value here: _____

NOTE It is important to record the negative or positive value.

Step 8. Divide the value by 2 and record the value here: _____

This adapter delay value will be used in the “Calibration” on page 6-5 step 10.

Calibration

Step 1. Connect two (2) 3.5 mm flexible test port cables to Port 1 and Port 2 of the network analyzer.

Step 2. Connect the APC-7 to 3.5 mm adapter to the end of the test Port 2 cable.

Step 3. Perform the first full two-port calibration using a 3.5 mm calibration kit. Use the 3.5 mm standards.

Step 4. When the isolation calibration is performed, set the averaging to 16.

Step 5. Save the calibration to the internal disk and label it "Cal1".

Step 6. Perform the second full two-port calibration using a 7 mm calibration kit. Use the 7 mm standards. The Port 1 reference plane is the 7 mm to 3.5 mm adapter.

Step 7. When the isolation calibration is performed, set the averaging to 16.

Step 8. Save the calibration to the internal disk and label it "Cal2".

Step 9. Press:
[CAL] > **MORE** > **ADAPTER REMOVAL** > **HELP ADAPTER REMOVAL**

Step 10. Remove the adapter and use the value recorded in step 8 of the “Adapter Delay Removal” on page 6-4 for the adapter delay.

Step 11. Save the calibration and the instrument state in the internal memory and label as "Test".

Step 12. Mark the adapter on Port 2 to indicate the port adapter reference.

Step 13. Perform an adapter removal calibration from 300 kHz to 6 GHz.

Step 14. Make sure the calibration is active.

Step 15. Save the calibration into the analyzer internal disk by pressing:
[SAVE/RECALL] > **SAVE STATE**

NOTE The isolation calibration routine is done with 16 averages.

Testing for Insertion Loss

Step 1. Recall the adapter removal calibration from the analyzer internal disk by pressing:
[SAVE/RECALL] > SAVE STATE

Step 2. Connect the cable attached to Port 1 of the network analyzer to the Transmission port of the test set.

Step 3. Connect the cable from Port 2 of the network analyzer to Port 1 of the test set.

Step 4. Select the “all_term” command using the network analyzer by pressing:
[SEQ] > TTL I/O > PARALLEL ALL OUT > [34] > [x1]

(For complete information on controlling the test set, refer to Chapter 5, “Controlling the Test Set and Making Measurements,” on page 5-1.)

This command will ensure that no conflicts will occur when selecting the test set ports.

NOTE Reflection and Transmission cannot be directed to the same port. If the test set does not switch to the port you have selected, switch the other port to either 1 or 4.

Step 5. Select "Transmission Port 1" by pressing:
[SEQ] > TTL I/O > PARALLEL ALL OUT
Enter the decimal value (D in Table 5-1 on page 5-6) to select the port, then press:
[x1]

Step 6. Check the status LCD on the test set to verify the port has been selected.

Step 7. On the network analyzer, press:
[MENU] > TRIGGER MENU > SINGLE

Wait until the analyzer is finished taking a sweep, then press:
[SCALE REF] > AUTO SCALE > [MARKER]

Step 8. Using the front panel knob, locate the minimum value of the data trace for the 300 kHz to 6 GHz frequency range.

Step 9. Write the minimum value in the “Insertion Loss Test Record,” Table 6-1 on page 6-11, for the port being measured.

Step 10. Repeat steps 5 through 9 for the other frequency ranges listed in the “Insertion Loss Test Record”

Step 11. Repeat steps 5 through 10 for the remaining Transmission test ports (1 through 16)

Step 12. After all Transmission ports have been measured, move the cable attached to the Transmission port to the Reflection port on the test set. Repeat steps 5 through 11, but select the Reflection ports instead of the Transmission ports.

Testing for Isolation

Isolation needs to be measured only on adjacent ports. Two 50 Ω loads are required for this test.

Step 1. Recall the adapter removal calibration stored previously in the internal memory of the network analyzer

Step 2. Connect two (2) high-quality 50 Ω loads to both the Transmission and Reflection ports on the test set.

Step 3. Turn the averaging on by pressing:
[AVG] > **AVERAGING ON**

Step 4. Connect the two cables that are attached to the network analyzer to Port 1 and Port 2 of the test set. The exact order does not matter.

Step 5. Select "Reflection Port 1" on the network analyzer by pressing:
[SEQ] > **TTL I/O** > **PARALLEL ALL OUT**
Enter the decimal (D in Table 5-1 on page 5-6) value to select the port, then press:
[x1]
Check the status LCD on the network analyzer for the port selected.

Step 6. Repeat the previous step (step 5), but select "Transmission Port 2" on the network analyzer. Check the status LCD on the test set for the port selected.

Step 7. On the network analyzer, press:
[MENU] > **TRIGGER MENU** > **NUMBER OF GROUPS** > **[16]** > **[x1]**
Wait until the analyzer is finished making the measurement, then press:
[SCALE REF] > **AUTO SCALE** > **[MARKER]**

Step 8. On the analyzer, press:
MARKER FCTN > **MKR SEARCH** > **TRACKING** > **ON** > **SEARCH** > **MAX**

NOTE Once the marker tacking is turned on, the user no longer needs to repeat step 8

Step 9. Write the maximum value in the “Isolation Test Record”, Table 6-2 on page 6-13, for the ports being measured.

Step 10. Repeat steps 5 through 9 for the next two adjacent ports, 2 and 3. Repeat again for ports 3 and 4, and then for ports 4 and 5, and so on until you have tested ports 15 and 16.

Testing for Return Loss

This test will check both the internal termination load of each port, as well as the through match when the appropriate input port is terminated with a 50 Ω load.

Set up the network analyzer using the following procedure.

Step 1. Set the number of points to 401 by pressing:
[MENU] > **NUMBER OF POINTS** > **[401]**

Step 2. Set the IF Bandwidth to 10 Hz by pressing:
[AVG] > **IF BW** > **[10]** > **[x1]**

Step 3. Perform a one-port S_{11} calibration at the end of the test port cable connected to Port 1 of the analyzer.

Step 4. Make sure the calibration is active.

Step 5. Save the calibration into the internal memory of the network analyzer by pressing:
[SAVE/RECALL] > **SAVE STATE**

Step 6. Verify the calibration is active and accurate using a short connected to the test port cable.

Step 7. Locate the maximum and minimum values of the data trace by pressing:
[MARKER]
and using the front panel knob. The displayed return loss should measure ± 0.2 dB.

Step 8. Connect the cable (already connected to Port 1 of the analyzer) to Port 1 of the test set.

Step 9. Connect a high-quality 50 Ω load to the Transmission port of the test set.

Step 10. Select the “all_term” command using the network analyzer by pressing:
[SEQ] > **TTL I/O** > **PARALLEL ALL OUT** > **[34]** > **[x1]**
This command will ensure that no conflicts will occur when selecting the test set ports.

Step 11. Select "Transmission Port 1", on the network analyzer by pressing:
[SEQ] > **TTL I/O** > **PARALLEL ALL OUT**
Enter the decimal value (D in Table 5-1 on page 5-6) to select the port, then press:
[x1]
Check the status LCD to verify the port selected.

Step 12. On the network analyzer, press:
[MENU] > **TRIGGER MENU**
Wait until the analyzer is finished taking a sweep, then press:
[SCALE REF] > **AUTO SCALE** > **[MARKER]**

Step 13. Using the front panel knob, locate the maximum value of the data trace for the 50 MHz to 2.0 GHz frequency range.

Step 14. Write the maximum value in the “Return Loss Test Record”, Table 6-3 on page 6-14, for the port being measured.

Step 15. Repeat the previous two steps for the other frequency ranges listed in the “Return Loss Test Record”.

Step 16. Press:
[SEQ] > **TTL I/O** > **PARALLEL OUT ALL** > **[34]** > **[x1]**

Step 17. Using the front panel knob, locate the maximum value of the data trace for the 50 MHz to 2.0 GHz frequency range.

Step 18. Write the maximum value in the “Return Loss Test Record”, Table 6-3 on page 6-14, for the port being measured.

Step 19. Repeat steps 10 through 18 for the remaining test ports (2 through 16).

Step 20. After all Transmission ports have been measured, move the high-quality load attached on the Transmission port to the Reflection port on the test set. Repeat steps 10 through step 19, but select the Reflection ports instead of the Transmission ports.

This completes the performance testing instructions.

Performance Test Record

NOTE This page and the following pages (Performance Test Record) are designed to be duplicated and used as a template for either of the Transmission or Reflection ports during each of the performance tests (Insertion Loss, Return Loss, and Isolation). At the top of each page, circle the appropriate input port, Transmission or Reflection, and write in the test date.

Agilent 87050A Option H15 Test Record

Test Facility _____ Report Number _____

_____ Date _____

_____ Date of Last System Calibration _____

_____

Tested by _____ Customer _____

Model _____ Serial Number _____

Ambient Temperature _____° C Relative Humidity _____%

Test Equipment Used	Model Number	Trace Number	Cal Due Date
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Special Notes:

_____

_____

_____

_____

_____

Transmission/Reflection **Date**_____

Table 6-1 Agilent 87050A Option H15 Insertion Loss Test Record (1 of 2)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Insertion Loss	1	≤1.5	_____	±0.3
300 kHz up to 1.3 GHz	2	≤1.5	_____	±0.3
	3	≤1.5	_____	±0.3
	4	≤1.5	_____	±0.3
	5	≤1.5	_____	±0.3
	6	≤1.5	_____	±0.3
	7	≤1.5	_____	±0.3
	8	≤1.5	_____	±0.3
	9	≤1.5	_____	±0.3
	10	≤1.5	_____	±0.3
	11	≤1.5	_____	±0.3
	12	≤1.5	_____	±0.3
	13	≤1.5	_____	±0.3
	14	≤1.5	_____	±0.3
	15	≤1.5	_____	±0.3
	16	≤1.5	_____	±0.3
Insertion Loss	1	≤1.75	_____	±0.3
1.3 GHz up to 3.0 GHz	2	≤1.75	_____	±0.3
	3	≤1.75	_____	±0.3
	4	≤1.75	_____	±0.3
	5	≤1.75	_____	±0.3
	6	≤1.75	_____	±0.3
	7	≤1.75	_____	±0.3
	8	≤1.75	_____	±0.3
	9	≤1.75	_____	±0.3
	10	≤1.75	_____	±0.3
	11	≤1.75	_____	±0.3
	12	≤1.75	_____	±0.3
	13	≤1.75	_____	±0.3
	14	≤1.75	_____	±0.3
	15	≤1.75	_____	±0.3
	16	≤1.75	_____	±0.3

Transmission/Reflection **Date**_____

Table 6-1 Agilent 87050A Option H15 Insertion Loss Test Record (2 of 2)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Insertion Loss	1	≤2.5	_____	±0.3
3.0 GHz to 6.0 GHz	2	≤2.5	_____	±0.3
	3	≤2.5	_____	±0.3
	4	≤2.5	_____	±0.3
	5	≤2.5	_____	±0.3
	6	≤2.5	_____	±0.3
	7	≤2.5	_____	±0.3
	8	≤2.5	_____	±0.3
	9	≤2.5	_____	±0.3
	10	≤2.5	_____	±0.3
	11	≤2.5	_____	±0.3
	12	≤2.5	_____	±0.3
	13	≤2.5	_____	±0.3
	14	≤2.5	_____	±0.3
	15	≤2.5	_____	±0.3
	16	≤2.5	_____	±0.3

Transmission/Reflection **Date**_____

Table 6-2 Agilent 87050A Option H15 Isolation Test Record (1 of 1)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Isolation	1	≥100	_____	±5
300 kHz up to 3.0 GHz	2	≥100	_____	±5
	3	≥100	_____	±5
	4	≥100	_____	±5
	5	≥100	_____	±5
	6	≥100	_____	±5
	7	≥100	_____	±5
	8	≥100	_____	±5
	9	≥100	_____	±5
	10	≥100	_____	±5
	11	≥100	_____	±5
	12	≥100	_____	±5
	13	≥100	_____	±5
	14	≥100	_____	±5
	15	≥100	_____	±5
	16	≥100	_____	±5
Isolation	1	≥90	_____	±5
3.0 GHz to 6.0 GHz	2	≥90	_____	±5
	3	≥90	_____	±5
	4	≥90	_____	±5
	5	≥90	_____	±5
	6	≥90	_____	±5
	7	≥90	_____	±5
	8	≥90	_____	±5
	9	≥90	_____	±5
	10	≥90	_____	±5
	11	≥90	_____	±5
	12	≥90	_____	±5
	13	≥90	_____	±5
	14	≥90	_____	±5
	15	≥90	_____	±5
	16	≥90	_____	±5

Transmission/Reflection **Date**_____

Table 6-3 Agilent 87050A Option H15 Return Loss Test Record (1 of 3)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Return Loss	1	≥25	_____	±1.5
300 kHz up to 1.3 GHz	2	≥25	_____	±1.5
Switch Path ON	3	≥25	_____	±1.5
	4	≥25	_____	±1.5
	5	≥25	_____	±1.5
	6	≥25	_____	±1.5
	7	≥25	_____	±1.5
	8	≥25	_____	±1.5
	9	≥25	_____	±1.5
	10	≥25	_____	±1.5
	11	≥25	_____	±1.5
	12	≥25	_____	±1.5
	13	≥25	_____	±1.5
	14	≥25	_____	±1.5
	15	≥25	_____	±1.5
	16	≥25	_____	±1.5
Return Loss	1	≥16	_____	±1.5
1.3 GHz up to 3.0 GHz	2	≥16	_____	±1.5
Switch Path ON	3	≥16	_____	±1.5
	4	≥16	_____	±1.5
	5	≥16	_____	±1.5
	6	≥16	_____	±1.5
	7	≥16	_____	±1.5
	8	≥16	_____	±1.5
	9	≥16	_____	±1.5
	10	≥16	_____	±1.5
	11	≥16	_____	±1.5
	12	≥16	_____	±1.5
	13	≥16	_____	±1.5
	14	≥16	_____	±1.5
	15	≥16	_____	±1.5
	16	≥16	_____	±1.5

Transmission/Reflection **Date**_____

Table 6-3 Agilent 87050A Option H15 Return Loss Test Record (2 of 3)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Return Loss	1	≥12	_____	±0.6
3.0 GHz up to 6.0 GHz	2	≥12	_____	±0.6
Switch Path ON	3	≥12	_____	±0.6
	4	≥12	_____	±0.6
	5	≥12	_____	±0.6
	6	≥12	_____	±0.6
	7	≥12	_____	±0.6
	8	≥12	_____	±0.6
	9	≥12	_____	±0.6
	10	≥12	_____	±0.6
	11	≥12	_____	±0.6
	12	≥12	_____	±0.6
	13	≥12	_____	±0.6
	14	≥12	_____	±0.6
	15	≥12	_____	±0.6
	16	≥12	_____	±0.6
Return Loss	1	≥26	_____	±1.5
300 kHz up to 1.3 GHz	2	≥26	_____	±1.5
Switch Path OFF	3	≥26	_____	±1.5
	4	≥26	_____	±1.5
	5	≥26	_____	±1.5
	6	≥26	_____	±1.5
	7	≥26	_____	±1.5
	8	≥26	_____	±1.5
	9	≥26	_____	±1.5
	10	≥26	_____	±1.5
	11	≥26	_____	±1.5
	12	≥26	_____	±1.5
	13	≥26	_____	±1.5
	14	≥26	_____	±1.5
	15	≥26	_____	±1.5
	16	≥26	_____	±1.5

Transmission/Reflection **Date**_____

Table 6-3 Agilent 87050A Option H15 Return Loss Test Record (3 of 3)

Test Description	Port	Specification (dB)	Measured Results (dB)	Measurement Uncertainty (dB)
Return Loss	1	≥21	_____	±1.5
1.3 GHz up to 3.0 GHz	2	≥21	_____	±1.5
Switch Path OFF	3	≥21	_____	±1.5
	4	≥21	_____	±1.5
	5	≥21	_____	±1.5
	6	≥21	_____	±1.5
	7	≥21	_____	±1.5
	8	≥21	_____	±1.5
	9	≥21	_____	±1.5
	10	≥21	_____	±1.5
	11	≥21	_____	±1.5
	12	≥21	_____	±1.5
	13	≥21	_____	±1.5
	14	≥21	_____	±1.5
	15	≥21	_____	±1.5
	16	≥21	_____	±1.5
Return Loss	1	≥15	_____	±0.6
3.0 GHz up to 6.0 GHz	2	≥15	_____	±0.6
Switch Path OFF	3	≥15	_____	±0.6
	4	≥15	_____	±0.6
	5	≥15	_____	±0.6
	6	≥15	_____	±0.6
	7	≥15	_____	±0.6
	8	≥15	_____	±0.6
	9	≥15	_____	±0.6
	10	≥15	_____	±0.6
	11	≥15	_____	±0.6
	12	≥15	_____	±0.6
	13	≥15	_____	±0.6
	14	≥15	_____	±0.6
	15	≥15	_____	±0.6
	16	≥15	_____	±0.6

Replaceable Parts

Table 6-4 Replaceable Parts

Replacement Part	Agilent Part Number	Quantity
Power Supply, 110 W	0950-2252	1
Adapter, 3.5 mm to APC 7	1250-1747	2
Feet, Spring	1460-1345	2
Termination, 50 Ω	1810-0118	6
Fuse, Daughter Control Board	2110-0158	1
Fuse, 3 A 250 V f, ac Line Module	2110-0780	2
Cover, Top	5002-1047	1
Cover, Bottom	5002-1088	1
Cover, Side	5002-3985	2
Shield	5002-4017	1
Frame, Rear	5021-5806	1
Strut, Side	5021-5837	4
Frame, Front	5022-1189	1
Foot	5041-9167	4
Trim, Front Frame Side	5041-9173	2
Trim, Top	5041-9176	1
Front Cap, Strap Handle	5041-9186	2
Rear Cap, Strap Handle	5041-9187	2
Standoff, Rear Panel	5041-9188	4
Handle, Strap	5063-9210	2
Kit, Front Handle	5063-9228	1
Kit, Rack Mount	5063-9235	1
Cable, Type-N (m) to Type-N (m)	8120-6995	1
Parallel Cable	8120-6818	1
IDSS Cable Strip	8120-8794	1
Cable Tie	9310-6480	1
Assembly, Switch	08711-60129	1
Rear Panel *	08720-00102	1
Bracket, Switch*	08720-00103	3
Wire Harness, Multiport*	08720-60191	1
Switch Assembly, 33314c-024	33314-60012	16
Adapter, APC-7 to Type-N (m)	85054-60001	1
Switch Support (12sw)*	87050-00020	1
Deck*	87050-00021	1

Table 6-4 Replaceable Parts

Replacement Part	Agilent Part Number	Quantity
RF Cable, J15-6 to J51-1, J16-6 to J57-1*	87050-20079	2
RF Cable, J14-5 to J51-1*	87050-20080	1
RF Cable, J15-6 to J53-1*	87050-20081	1
RF Cable, J15-5 to J62-1, J16-5 to J68-1*	87050-20082	2
RF Cable, J15-2 to J64-1, J16-2 to J70-1*	87050-20083	2
RF Cable, J14-3 to J66-1*	87050-20084	1
RF Cable, J15-4 to J63-1, J16-4 to J69-1*	87050-20085	2
RF Cable, J15-3 to J65-1, J16-3 to J71-1*	87050-20086	2
RF Cable, J14-4 to J67-1*	87050-20087	1
RF Cable, J10-6 to J51-2, J11-6 to J57-2*	87050-20091	2
RF Cable, J10-3 to J53-2*	87050-20092	1
RF Cable, J12-2 to J55-2*	87050-20093	1
RF Cable, J10-5 to J62-2, J11-5 to J68-2*	87050-20094	2
RF Cable, J12-6 to J64-2*	87050-20095	1
RF Cable, J12-3 to J66-2*	87050-20096	1
RF Cable, J10-4 to J63-2, J11-4 to J69-2*	87050-20097	2
RF Cable, J12-5 to J65-2*	87050-20098	1
RF Cable, J12-4 to J67-2*	87050-20099	1
RF Cable, J18-6 to J15-C*	87050-20100	1
RF Cable, J18-5 to J14-C*	87050-20101	1
RF Cable, J18-3 to J16-C*	87050-20102	1
RF Cable, J10-C to J19-6*	87050-20104	1
RF Cable, J12-C to J19-5*	87050-20105	1
RF Cable, J11-C to J19-3*	87050-20106	1
RF Cable, J63-C to Port 1*	87050-20158	1
RF Cable, J62-C to Port 2*	87050-20159	1
RF Cable, J51-C to Port 3*	87050-20160	1
RF Cable, J65-C to Port 4*	87050-20161	1
RF Cable, J64-C to Port 5*	87050-20162	1
RF Cable, J53-C to Port 6*	87050-20163	1
RF Cable, J67-C to Port 7*	87050-20164	1
RF Cable, J66-C to Port 8*	87050-20165	1
RF Cable, J55-C to Port 9*	87050-20166	1
RF Cable, J69-C to Port 10*	87050-20167	1
RF Cable, J68-C to Port 11*	87050-20168	1
RF Cable, J57-C to Port 12*	87050-20169	1
RF Cable, J71-C to Port 13*	87050-20170	1

Table 6-4 Replaceable Parts

Replacement Part	Agilent Part Number	Quantity
RF Cable, J70-C to Port 14*	87050-20171	1
RF Cable, J73-C to Port 15*	87050-20172	1
RF Cable, J72-C to Port 16*	87050-20173	1
RF Cable, J10-2 to J70-2*	87050-20174	1
RF Cable, J12-1 to J71-2*	87050-20175	1
RF Cable, J14-1 to J72-1*	87050-20176	1
RF Cable, J15-1 to J73-1*	87050-20177	1
RF Cable, J11-3 to J72-2*	87050-20178	1
RF Cable, J10-1 to J73-2*	87050-20179	1
RF Cable, J18-C to Reflection*	87050-20180	1
RF Cable, J19-C to Trans.*	87050-20181	1
Wire Harness, 04c, 0.3m, 13f-06f	87050-60021	1
Wire Harness, 04c, 0.13m, 04f-04f	87050-60022	1
Wire Harness, 40c, 0.09m, 40f-40f	87050-60023	3
Fan Assembly 5 cfm	87050-60027	1
Daughter Control Board	87050-60050	1
Ribbon Cable 16c 16f/16f	87050-60055	8
Wire Harness, Multiport*	87050-60070	1
Front Panel Subassembly*	87050-60169	1
Controller Mother Board *	87050-60170	1
Display Subassembly *	87050-60193	1
User's and Service Guide*	87050-90029	1
Bracket, Fan	87075-00005	1
Switch, 1p4t 26.5	87104-60001	2
Switch, 1p6t 26.5	87106-60009	6
Cable Assembly, AC Line	87130-60007	1
Power Cord	See Figure 3-3	1

NOTE The parts indicated with an asterisk (*) are unique to this special option. To order replacement parts, please contact the Component Test PGU at (707) 577-6802 with the part number, module/model number, and option number. If ordering parts through your local Agilent Technologies Sales or Service Office, specify that asterisk parts are ordered through the Component Test PGU.

NOTE Special options are built to order, therefore long lead times may be encountered when ordering replacement parts.

Troubleshooting the Test Set

This section contains information on troubleshooting the test set to the assembly level only. By following these procedures you should be able to determine whether the power supply, front panel, or main switch board needs replacing. A block diagram is included at the end of this section as an aid in troubleshooting.

Theory of operation information can be found in the next section of this manual.

General Troubleshooting Notes

WARNING **Always turn the instrument power off before removing or installing an assembly.**

CAUTION If you need to disassemble the instrument, be sure to work at an antistatic workstation and use a grounded wrist strap to prevent damage from electrostatic discharge (ESD). Refer to Figure 1-3 on page 1-7.

Troubleshooting Power Supply Problems

Turn the instrument on. Check the condition of the LCD on the front panel:

Step 1. If the LCD is off, check the main fuse located in the power supply filter at the rear of the instrument.

Step 2. If the LCD is off, there is still a possibility that the power supply is not supplying the necessary +24 V, +12 V, and +5 V to the main board. Check the cable connection between the main board and the front panel board.

Step 3. Finally, disconnect the DC power cable from the power supply to the main switch board and measure the voltages. They should be +24 V, +12 V, and +5 V. If not, replace the power supply.

Troubleshooting the Front Panel Board

Turn the instrument power on and do the following:

Step 1. Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the Transmission or Reflection path. Ensure that the LCD indicates the appropriate path.

Step 2. If the LCD indicates a wrong path, the problem can lie with either the front panel board or the main switch board. Measure the RF path to determine where the problem is.

Step 3. If the LCD does not display the proper path, check to see if the RF path has indeed been switched. If the problem lies with the front panel board, replace the board.

Troubleshooting the Controller and Switch Driver Boards

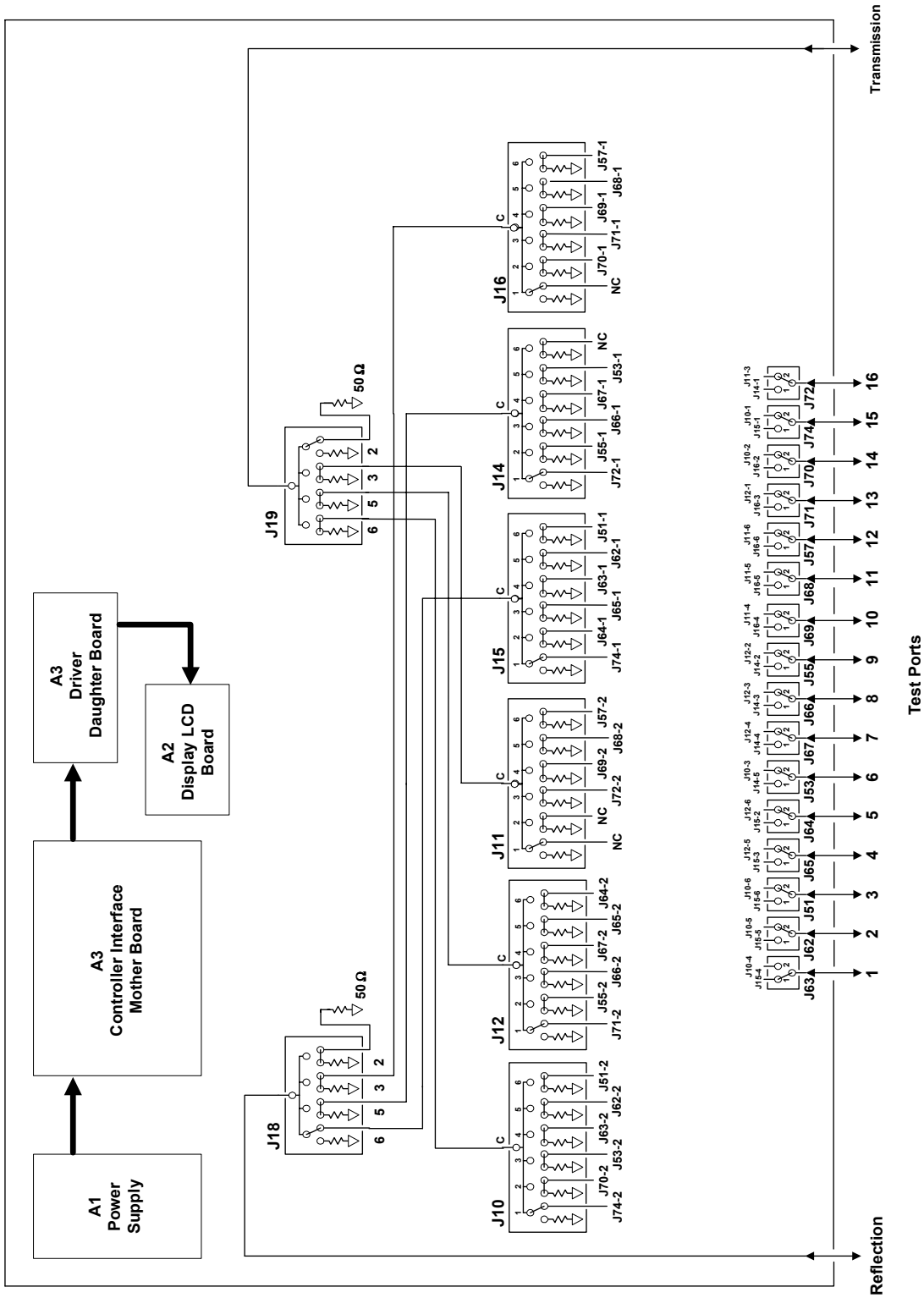
Turn the instrument power on and do the following:

Step 1. Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the Transmission or Reflection path.

Step 2. Check the RF paths for connection. If an RF path is not connected to the necessary port or terminated in 50 Ω, replace the controller and switch driver board.

A block diagram for the Agilent 87050A Option H15 is provided on the following page. Refer to Figure 6-1 on page 6-22.

Figure 6-1 **Block Diagram of the Agilent 87050A Option H15**



Theory of Operation

The theory of operation begins with a general description of the Agilent 87050A Option H15 multiport test set. This is followed by more detailed operating theory. The operation of each group is described briefly, to the assembly level only. Detailed component level circuit theory is not provided.

System Theory

The test set consists of three main components:

- power supply
- front panel display
- controller interface mother board

The purpose of the power supply is to provide power to both the front panel display and the main switch board. The front panel display serves to indicate the switching paths to the user. Finally, the controller interface mother board does the actual switching between the different ports.

A1 Power Supply Theory

The switching power supply provides regulated dc voltages to power all assemblies in the test set. A dc cable provides power to the main switch board. A connector from the main switch board to the front panel display provides dc power and control signals to the front panel. The power supply provides the following voltages: +24 V, +12 V, and +5 V.

A2 Front Panel Display Theory

The front panel display consists of an LCD. The LCD is divided into two sections, Reflection and Transmission. The first section indicates which of the ten ports is connected to the Reflection port. The second section indicates which of the sixteen ports is connected to the Transmission port. Control signals and dc power are provided by a cable connected to the main switch board.

A3 Controller Board (Mother Board) and Switch Driver Board (Daughter Board) Theory

Refer to the block diagram, Figure 6-1 on page 6-22, for the following discussion.

The mother and daughter boards provide the bias for the switching paths for the various ports to the Transmission and Reflection ports. The front panel display contains an LCD that indicates the switched ports. A particular test port (1 through 16) can be in one of three states. The three states are as follows:

- Switched to the forward path
- Switched to the reverse path
- Terminated in 50 Ω

When a port is not connected, it is automatically terminated in 50 Ω.

The test set consists of sixteen (16) 1 by 2 switches, six (6) 1 by 6 switches, and two (2) 1 by 4 switches. The 1 by 2 switches divide each of the input ports (1 through 16) into two separate paths, the Transmission path or the Reflection path.

Each path, Transmission or Reflection, connects to a bank of three (3) 1 by 6 switches (for a total of six (6) 1 by 6 switches). The 1 by 6 switches connect to a bank of two (2) 1 by 4 switches. Each bank of 1 by 6 switches connects to a single 1 by 4 switch where it connects to either the Transmission or Reflection port.

All switches are mechanical, and are biased according to the necessary switching path. A user interface through the GPIB and parallel ports converts the necessary input signals from the user to the necessary signals controlling the switching paths.

7 Safety and Regulatory Information

Safety and Regulatory Information

Introduction

Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate the instrument. This product has been designed and tested in accordance with international standards.

Cleaning Instructions

Clean the instrument cabinet using a damp cloth only.

Shipping Instructions

Always transport or ship the instrument using the original packaging if possible. If not, comparable packaging must be used.

Before Applying Power

Verify that the product is configured to match the available main power source as described in the input power configuration instructions in this manual. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

Safety Information

Warnings

WARNING **The WARNING notice denotes a hazard. It calls attention to a procedure, practice, or the like, which if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.**

Warnings applicable to this instrument are:

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

WARNING **If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in a normal condition (in which all means for protection are intact) only.**

WARNING **For continued protection against fire hazard replace line fuse only with same type and rating:**
• United States—F 3A/250V, Part Number 2110-0780
• Europe—F 3.15A/250V, Part Number 2110-0655
The use of other fuses or material is prohibited.

WARNING **This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

WARNING **The power cord is connected to internal capacitors that may retain dangerous electrical charges for 5 seconds after disconnecting the plug from its power supply.**

WARNING **These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

WARNING **The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.**

WARNING **This product is designed for use in Installation Category II and Pollution Degree 2 per IEC 1010 and 664 respectively.**

Cautions

CAUTION The CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like, which if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

Cautions applicable to this instrument are:

CAUTION Always use the three-prong ac power cord supplied with this instrument. Failure to ensure adequate earth grounding (by not using this cord) can cause instrument damage.

CAUTION This instrument has autoranging line voltage input; be sure the supply voltage is within the specified range.

CAUTION Ventilation Requirements: When installing the instrument in a cabinet, the convection into and out of the instrument must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the instrument by 4° C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, forced convection must be used.

Instrument Markings

	When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
	This symbol indicates that the instrument requires alternating current (ac) input.
	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
ISM1-A	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).
	This symbol indicates that the power line switch is ON.
	This symbol indicates that the power line switch is OFF or in STANDBY position.
 N279	This symbol indicates the product meets the Australian Standards.

Safety Earth Ground

This is a Safety Class I product (provided with a protective earthing terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation.

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